Assessing the Impact of Colloids on the Disposal of Radioactive Waste Glass at Yucca Mountain

Colloidal systems encompass a wide variety of surface-active agents and dispersed particles. Because of their sub-micron size and surface charge properties, colloidal systems have the potential to transport radioactive contaminants from a waste storage or disposal site to the subsurface groundwater. Indeed, recent studies at the Nevada Test Site have confirmed the mobility of colloidal plutonium in the subsurface and accentuate the importance of colloids in the modeling of waste form performance. To evaluate the impact of colloids on radioactive waste disposal at Yucca Mountain, the Waste Materials Research Department in CMT is characterizing the physical and chemical nature of the solution-borne colloids that form during waste-form degradation. The focus of our work is on understanding the formation and properties of radionuclide-bearing colloids that affect their transport and mobility in a subsurface environment.

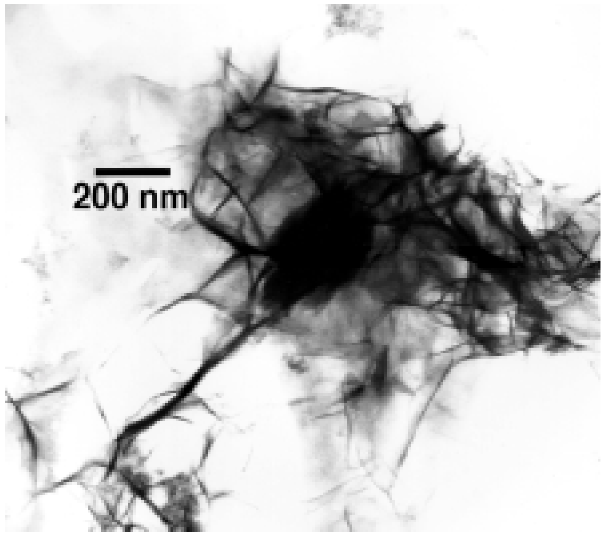
Over the past several years, static corrosion tests have been underway on several representative compositions of Defense Waste Processing Facility glass in groundwater from Yucca Mountain. These laboratory studies of colloidal properties are important to determine the mechanism of colloid formation and colloid stability during waste form corrosion. A variety of techniques, including transmission electron microscopy (TEM), dynamic light scattering (DLS), and nuclear spectroscopy, have been employed to characterize the colloids generated in the corrosion tests.

Results from the TEM colloid analyses indicated that smectite clay colloids form during glass corrosion and contain discrete radionuclide-bearing phases incorporated in the clay (see figure on next page). Americium and plutonium were identified in the brockite inclusion rather than in the clay colloid matrix. The mineralogical composition of the colloids, as determined by TEM analyses, was found to be important for understanding and predicting the stability of the colloids. The DLS results have been instrumental in correlating the bulk-solution colloidal properties (colloid size and concentration) with the compositional results from TEM and the radionuclide distribution from filtration and alpha spectroscopy. In addition, DLS was employed to monitor the rate of colloid growth and changes in the size and diffusion of the colloids as a function of nuclear waste glass corrosion. Under the reaction kinetics of these corrosion tests, stable colloids were observed in low ionic strength solutions (below about 0.05 mol/kg). However, as the ionic strength increased during the glass corrosion, aggregation of the colloidal species occurred. For waste glass corrosion, the colloid stability is thus governed by the properties of the clay and the geochemical environment.

The results from these studies demonstrate the importance of colloids for modeling waste form behavior. Ongoing and future studies include predicting colloid formation and stability in other waste forms under repository-relevant conditions.

ANL Participants

Carol J. Mertz, Jeffrey A. Fortner, Stephen F. Wolf, James C. Cunnane, and William L. Ebert. For further information contact Carol Mertz at (630) 252-4394 or mertz@cmt.anl.gov.



Smectite Clay Colloid from a Corrosion Test with Nuclear Waste Glass Showing Entrained Particles of Brockite (thorium calcium orthophosphate mineral, dark regions within clay matrix)